Brief Communication

Maternal Sodium Intake Does Not Affect Postprandial Sodium Concentrations in Human Milk

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ABSTRACT Sodium concentration in human milk is known to vary diurnally and throughout lactation. To investigate potential postprandial variation, eight exclusively breast-feeding mothers of infants 10–19 wk of age were visited on two different days after a 3-h fast. On one day, they were fed a low sodium lunch (130 mg), and on the other, the same lunch with a high sodium content (2175 mg). Milk samples were collected before each lunch and breasts were emptied with an electric pump. After lunch, samples were collected from each breast every 15 min for 2 h. No significant postprandial variation was found in mean sodium or potassium concentrations, nor were significant differences found in sodium or potassium values after the high sodium or the low sodium lunch. We conclude that there is no significant influence of maternal sodium intake on postprandial milk sodium or potassium concentrations. *J. Nutr.* 117: 1154–1157, 1987.

INDEXING KEY WORDS:

• *lactation* • *infant nutrition* • *human milk* • *minerals*

Of all the minerals in human milk, the concentration of sodium is the most variable, fluctuating as much as 10-fold during normal full lactation (1). Milk sodium concentration is known to vary diurnally (2) and throughout lactation (1,3,4). Although some of the extreme variations in sodium may be due to elevated sodium during subclinical mastitis (5,6) and involution of the mammary gland accompanying weaning (7–9), much of the "normal" variability is unexplained.

Breast-feeding mothers commonly assume that a high salt diet will influence sodium levels in their milk. However, the influence of maternal sodium intake on milk sodium has not been fully investigated. In 1943, researchers demonstrated that radioactive sodium added to orange juice and consumed by lactating women was present in their milk within 20 min, with maximal levels within 2 h (10). Much later, De Filippi, Kaanders and Hofman (11) investigated the effects of reduced maternal salt intake during a 5-d period among 13 subjects. Mid-feed breast milk samples were taken three times a day, but no mention was made of the timing of sample collection relative to meals. They found no difference in the mean sodium concentration of breast milk between the low salt and control groups, despite a significantly lower salt intake and reduced urinary sodium excretion in the low salt group. Similar results were reported by Keenan et al. (2) on the basis of a study of six women who consumed a low sodium diet for 2 d. Again, timing of sample collection did not account for timing of meals. Neither study investigated the influence of increasing maternal sodium intake above customary intakes.

Because plasma sodium concentration is rapidly regulated via hormonal and osmotic mechanisms (12), it is possible that any effect of maternal diet on milk sodium would be transitory. Thus, collection of milk samples some time after a meal may show no relationship to sodium content of the meal. The present study was designed to determine whether there is any postprandial variation in milk sodium concentration after a low sodium or a high sodium meal.

METHODS

Sample. Subjects for the study were eight healthy, exclusively breast-feeding mothers. The mean age of the women was 29.6 yr, ranging from 28 to 33. Six of the eight customarily restricted their salt intake by not using salt at the table or while cooking. Infants ranged from 10 to 19 wk of age, with a mean of 14 wk. Subjects gave their informed consent to the procedures involved in the study, the protocol for which was approved by the Human Subjects Review Committee at the University of California, Davis.

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Data collection. Each subject was visited twice in the home. At one visit, a low sodium lunch was provided, and at the other, a high sodium version of the same lunch was given. The order in which the two meals were given was randomized. **Table 1** shows the composition of both lunches. The high sodium lunch provided 2.18 g sodium, which is similar to the average total nondiscretionary daily sodium intake among women 25–34 yr of age in the U.S. population (14). If the lunch is estimated to represent one-third of total daily sodium intake, this would correspond to 6.5 g sodium/d. On the assumption that discretionary sodium intake in the U.S. population is approximately 2 g/d (12), this intake would be similar to the 95th percentile of sodium intake among women 25–34 yr of age (14).

Each mother was asked ahead of time to store enough expressed breast milk in the freezer to feed the infant if necessary during the 2-h study. Mothers were asked not to eat or drink anything for at least 3 h prior to the visit.

Upon our arrival, the mother nursed the infant and a 10-mL mid-feed milk sample was collected from each breast. Any remaining milk after nursing was expressed with an electric pump. Lunch was given immediately after all milk was removed. After the lunch, breasts were rinsed with distilled water, and a 5-mL milk sample was collected from each breast every 15 min for 2 h, either manually or with an electric breast pump. After the 2-h period, any remaining milk was expressed with the electric pump to determine whether the rate of removal had approximated each mother's rate of production. Milk samples were expressed directly into acid-rinsed vials or pump bottles to avoid contamination. All samples were refrigerated and later frozen at −20°C until analyzed. Milk samples were digested with nitric acid, ashed and analyzed for sodium and potassium by flame atomic absorption spectrophotometry (IL 151, Instrumentation Laboratory, Wilmington, MA) by use of the emission mode.

Data analysis. One subject had great difficulty expressing milk samples, and required the infant to suckle in order to collect milk. She was therefore subsequently deleted from the analysis of data. Data were analyzed by comparing both the absolute values for milk sodium and potassium concentration after each lunch, and the same values expressed as a percentage of prelunch concentrations. Because comparison of milk samples from left and right breasts revealed no abnormal values indicative of subclinical mastitis, data from both breasts were averaged for the presentation of results. Weighted quadratic regression was used to determine whether there were any significant postprandial changes in absolute sodium or potassium concentrations. Because no postprandial trends were evident, simple paired *t*-tests at each time interval were used to compare high sodium and low sodium lunch concentrations of sodium and potassium (as percentages of prelunch values).

TABLE 1

Composition of lunches[1]

Ingredients	Low Na	High Na
Energy, *kcal*	739	734
CHO, *g*	65.5	64.9
Protein, *g*	29.7	29.3
Fat, *g*	39.8	39.7
Na, *mg*	131.6	2177
K, *mg*	667.2	842.5
Mg, *mg*	73.8	72.5
Zn, *mg*	1.86	1.86
Fe, *mg*	4.55	4.18
Ca, *mg*	634.1	614.5

[1]Based on values reported in Pennington and Church (13), with additional information on sodium content derived from food labels.

RESULTS

For most subjects, the rate of removal of milk approximated the rate of milk production, judging by the amount of milk that could be removed by pumping after the 2-h period of sequential milk sampling. In a few cases (1 or 2 subjects), more than 15 mL was collected from one breast after the 2-h period. The rate of removal of milk in this experiment (20 mL/h per breast) was similar to the rate of production reported by Neville et al. (15).

Figure 1 illustrates the variations in milk sodium and potassium concentrations after the low and high sodium meals. Sodium concentrations ranged from about 2 to 6 mM, whereas potassium ranged from about 9 to 14 mM. No significant postprandial variations in mean sodium or potassium concentrations were found after either meal. When sodium and potassium concentrations are expressed as a percentage of prelunch values (**Table 2**), no statistically significant differences were found between values after the low sodium or the high sodium lunch.

DISCUSSION

No significant postprandial variation in concentrations of breast milk sodium or potassium was found in this study. Although there is a diurnal pattern in milk sodium and potassium concentrations (2), this is apparently not related to meals. Keenan, Buzek and Garza (16) have demonstrated that the diurnal pattern of milk cortisol concentration is reciprocal to that of sodium but of a form similar to that of potassium; these authors have suggested that cortisol may regulate milk elec-

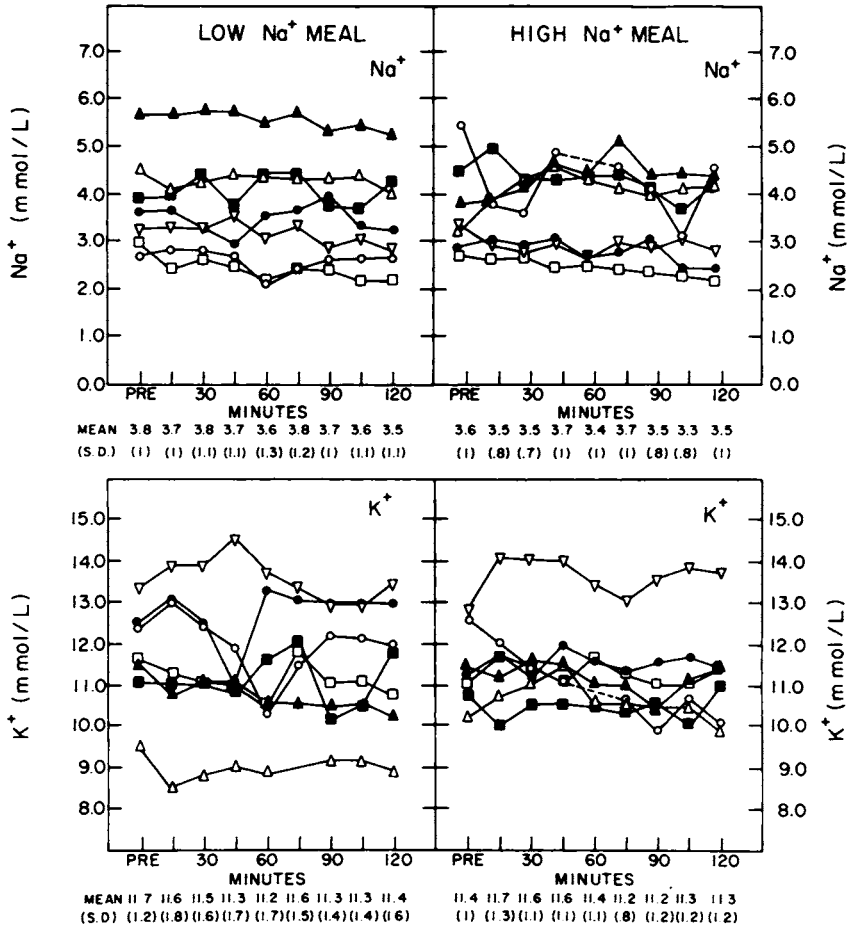

FIGURE 1 Sodium and potassium concentrations of milk from each subject after the low Na and the high Na meals.

trolytes by enhancing the effect of prolactin on sodium-potassium exchange in the mammary epithelium. Changes in the plasma levels of cortisol and prolactin during the day may therefore explain some of the variability of milk sodium concentrations, although the reason for greater variability in sodium than in potassium in milk remains unclear.

Information on postprandial variation of most other nutrients in breast milk is lacking. Using the same milk samples collected in the present study, Donovan, Dewey and Lönnerdal (17) found postprandial fluctuations in some of the nonprotein nitrogen components such as urea. Styslinger and Kirksey (18) have shown that the vitamin B-6 level in milk increases rapidly after administration of an oral supplement of vitamin B-6, reaching a peak at 4 h after the supplement is taken. In contrast, vitamin C levels in milk do not respond to maternal intake of vitamin C supplements (19), suggesting a reg-

TABLE 2

Milk Na and K concentrations as a percentage of prelunch values

			Minutes							
	Prelunch		15	30	45	60	75	90	105	120
			Low Na Lunch (n = 7)							
Na	Mean %	100	97.9	99.0	96.4	94.8	100.0	97.8	94.8	93.6
	SD	—	8.4	8.0	11.5	13.9	10.7	11.1	8.7	11.6
K	Mean %	100	99.3	98.1	96.5	96.1	99.4	95.9	97.2	98.0
	SD	—	6.0	3.7	6.2	9.2	6.7	4.4	3.7	6.6
			High Na Lunch (n = 7)							
Na	Mean %	100	98.0	100.0	106.9	104.0	106.8	101.4	95.8	100.1
	SD	—	16.4	21.4	20.3	19.7	19.6	17.4	21.2	20.1
K	Mean %	100	103.1	101.5	102.0	101.6	97.8	98.3	98.6	98.9
	SD	—	6.5	6.5	7.8	4.0	6.3	10.3	7.5	8.7

ulatory mechanism for this nutrient within the mammary gland. Thus, it appears that the components of human milk can be categorized by the degree to which they reflect postprandial fluctuations, and that this knowledge may be useful in understanding regulation of the physiological activity of the mammary gland.

Even though the subjects in our study were generally accustomed to a low salt diet, the high sodium lunch had no significant effect on milk sodium levels postprandially. These results are consistent with the scheme proposed by Peaker (20) for transport of sodium and potassium into and out of the secretory cells of the mammary gland. They hypothesize that intracellular sodium levels are kept low via a sodium pump on the basolateral cell membrane. Such a mechanism would regulate sodium concentrations in milk even if plasma sodium levels were elevated. Considering our results along with those of previous investigations (2,11), we conclude that there is no significant influence of maternal sodium intake on breast milk sodium or potassium concentration. Thus, future research on human milk sodium and potassium content need not account for variations in maternal sodium intake.

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